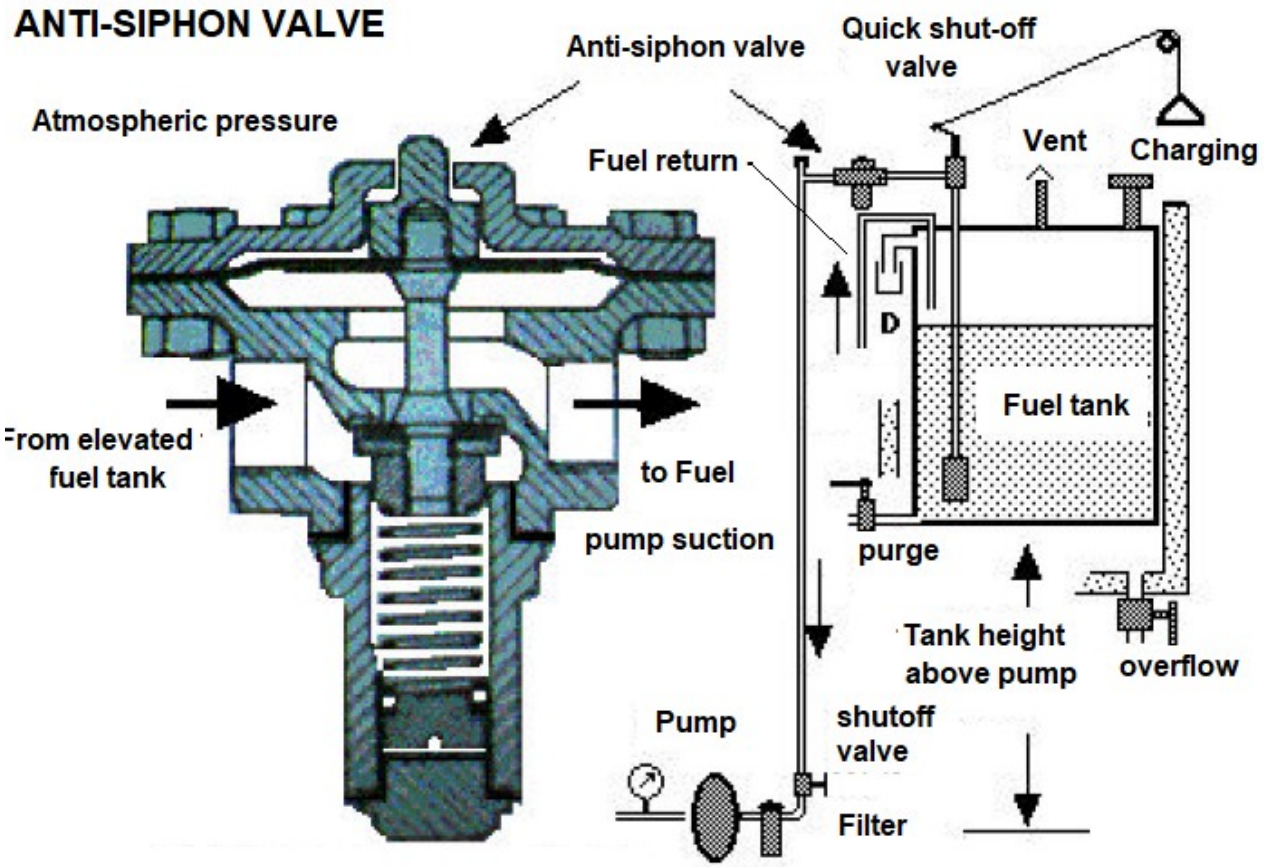
CHAPTER 5: Operation Part 2

ANTI-SIPHON VALVE

The risk with light fuels (diesel, diesel oil, and even highly heated fuel oil, etc.), when there is an elevated service tank, is spillage due to a lost connection, a broken pipe, or a hose.

To prevent this, anti-siphon devices are installed; that is, devices that prevent spillage due to gravity.

These siphons can be of the static type (pipes), solenoid valves, or dynamic type with anti-siphon valves. Let's look at an example of the latter:



Among the installation errors in fuel systems is the placement of a valve in the fuel return pipe: in this case, if someone closes it by mistake, the burner hose will "burst" due to excess pressure when the burner pump is turned on (if a valve is necessary, it is advisable

to install a check valve or a valve with a "by-pass" and a relief valve).

THE FUEL TANK:

The problem of fire must be considered a priority.

Depending on whether it is light fuel (Gas Oil, Diesel Oil, or Heating Oil) or heavy fuel (Heavy Fuel Oil, or No. 6 or Residual Fuel Oil, etc.), the appropriate accessories and tank design will vary.

For lighter fuels, the previous figure represents the case of a tank elevated above the burner (here, the problem of spillage due to siphoning or simple gravity must be considered by installing an anti-siphon valve, or a solenoid that activates only when the burner is lit, enabling suction from the tank, or a piping system that prevents the siphoning effect, creating an artificial "air chamber" in the suction line, so that the pump remains in suction if a rupture occurs in the hoses or pipes near the burner).

The spill containment tank in case of a rupture or overflow is not fully depicted in the previous tank diagram. Therefore, a lower tank with a larger capacity is required to receive the fuel in the event of a puncture or overflow.

These tanks are very sensitive to fuel "refilling," as they require both an automatic control system and a visual system for monitoring the maximum and minimum levels, along with a system for overflow (which should occur in a designated area).

The automatic level control systems must be appropriate, as the fuel has very low conductivity. Float systems suitable for the fuel and capable of withstanding the operating conditions are preferred.

There must always be adequate venting (outside the room), **a spill containment container in case of a tank puncture, and a designated area for containing any spilled fuel.** The tank's bottom drain should be located below the suction line (which must have a filter before the pump) to remove settled water.

However, when dealing with heavy fuel oil, the tank must have a heating system for pumping (since heavy fuel oil, when its

temperature is below 30°C (86°F) to 40°C (104°F), is almost impossible to pump due to its high viscosity).

The **heating system** (generally steam or hot water) must be located in the suction area of the transfer pump or the burner itself.

The suction foot or suction valve must have a **check valve** (which prevents the pipeline from losing its prime when under vacuum or with pressure dropping into the tank). This valve must have a seat with good sealing characteristics, such as Viton, which resists chemical attack and remains supple.
Furthermore, it must be protected by a **filter** made of an inert material that is not affected by the chemical properties of the water in the fuel, such as a **stainless steel mesh**.

It's always advisable to have both low and high fuel inlets. The high inlets can be used when working to avoid drawing in water, while the low inlets can be used when fuel is low. The inlets should be removable for maintenance, and each should have a top connection for priming whenever they are emptied for any reason.

These **heavy fuel oil tanks**, while they can be **above ground** (with an extra containment container in case the fuel spills due to a tank rupture), can also be **"underground",** but they must also **have an external sealed container for leaks or tank ruptures (so as not to contaminate the subsoil), and there must be a way to take samples from the bottom of this containment to see if there are any spills.**

All tanks, especially those for heavy fuel oil, must be properly insulated, even those for light fuels if they are exposed to the elements (as this would affect combustion by atomizing a very cold fuel).

Heavy fuel oil needs to be heated in the tank or kept warm at approximately 50°C (122°F), the temperature it usually receives from the ship or truck, so insulation prevents energy loss.

With heating fuel oil, even at ambient temperature, pumping problems from the tank to the burner can occur in cold weather.

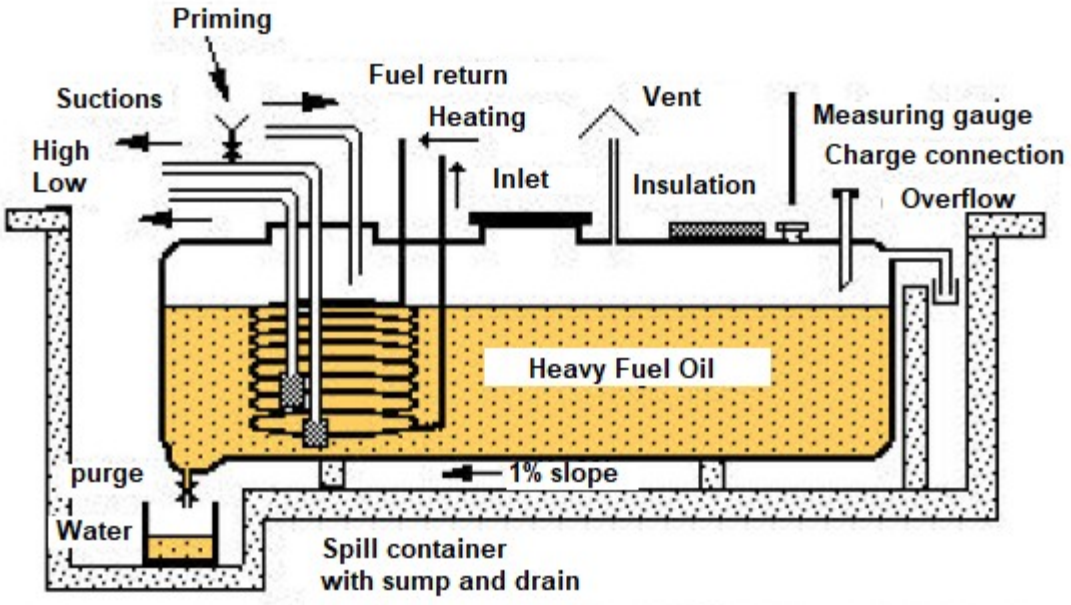
It is very important to understand that with underground tanks, even if they have two tanks, the problem of corrosion persists. Even

if the tank is painted, the presence of water or moisture in any pores on the protective paint surface will cause galvanic pitting, which will eventually perforate the tank within a few years.

To prevent this, the tank should be kept on a dry surface, usually sand, and **sacrificial anodes** (generally aluminum) can be installed. These anodes are connected to the tank and buried in the sand.

There can also be **corrosion inside the tank**, hence the importance of tilting the bottom of the tank towards the drain, in order to properly remove the water that comes with the fuel.

It is very important that the tank is "secured" to prevent "buoyancy", that is, with the tank empty, it can float because the safety tank or spill containment basin fills with water; therefore, the securing is important, since for every m3 of tank capacity, there will be 1,000 kg of buoyant force, minus the weight of the tank. **This buoyancy can break the connections or cause the tank to rotate, which is the same damage.**



BASIC SKETCH OF HEAVY FUEL OIL TANK

The Service Tank (F. Oil)

A service tank is not always necessary. A service tank is useful when the storage and receiving tanks are located far from the

pumps or burner suction lines, since a "depression" in the suction line with a heavy fuel makes pumping difficult (due to viscosity, the possible entry of air due to the pressure drop, small diameter piping, etc.).

Although the implementation of this tank presents several risks: the risk of fire, level control for fuel refilling (it can be automatic, but overflows occur if the automatic system fails; the overflow must be directed to a safe recovery area), and the fact that **the fuel must be heated** (at around 50°C/122°F, fuel vapors are produced, which are harmful to health and can cause an explosion if near an open flame or an electrical short circuit).

Furthermore, it requires **extra heating for cold starts**, and the fuel has high viscosity. There are also the problems of **purging accumulated water** due to settling (water separates more easily with slightly warmed fuel) and the release of gases or air drawn in by the burner pumps and returning to the service tank.

But the biggest problem is fuel spillage in the boiler room (there must be a lower container capable of receiving all the lost fuel, almost impossible if the transfer pump is still running).

To avoid this, a sealed, well-walled metal intermediate tank can be built with a **fuel reservoir for a few minutes to an hour of operation.** The fuel is pumped from this tank by a pump located near the main tank when the burner is in service, and any excess fuel is returned to the same tank.

This reservoir is pressurized for the burner pumps by its installation height above the burners and by the pressure loss in the return pipe (the return line is located at the top and returns to the main tank; all these pipes are of a good diameter, no less than 1 1/2" (for heavy fuels), insulated, and fitted with heating tracers, carrying away the gases and air, which then go to the main tank's vent).

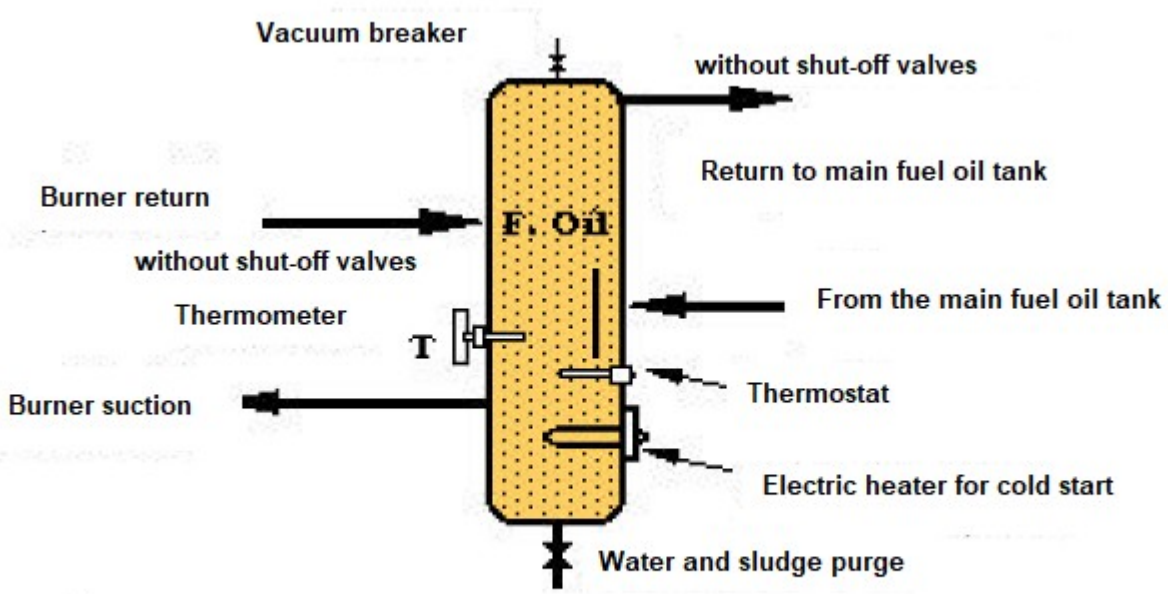
The burner feed is at an intermediate height to avoid drawing in sludge and water from the bottom of the reservoir, with the purge valve located at the bottom.

The burner return line is located closer to the reservoir return line to separate the gases at the top. The fuel inlet from the tank has a

baffle to separate gases, air, and water without creating a direct suction to the burners.

This tank must never be subjected to the pressure of the fuel pumps (i.e., if it has a valve on the return line to the main tank, it must have a relief valve in parallel with that shut-off valve).

When constructed, it **must withstand the working pressure without problems** (perform a hydraulic test). With very cold fuel, it may reach a higher pressure due to the effect of viscosity in the return line (therefore, the return line must be of generous diameter, insulated, and heated).



SEALED INTERMEDIATE FUEL TANK

THE FUEL HEATER IN THE BOILER

Next, the temperature must be raised for atomization, depending on the type of burner used. This will be achieved using either steam or electric heaters.

Steam heaters are generally of the vessel type, which may contain a steam coil, steam tubes, plates, and tubes (with a system to absorb the expansion of the body relative to the tubes located between the plates).

The most significant issue here is that the heater body may be subjected to the pressure of the atomization pumps (to prevent the pumps from being subjected to high temperatures, which causes rapid wear and tear and makes it difficult to maintain their efficiency) or to the low pressure of a low-pressure ring and the high-pressure pumps (which are subjected to high temperatures).

Since the **pumps are generally positive displacement** (that is, if their discharge is closed they raise the pressure to the mechanical limit of the system, as if it were a "screw"), this forces the pump and the heat exchanger body to have a relief valve system, in case someone closes the heater's discharge.

The other problem is the hydraulic expansion of the fuel (if we confine a liquid in an iron container and heat it, without any air or gas bubbles inside, the pressure can rise to the point where the container breaks or stretches, since the liquid will expand more than the container).

Therefore, if someone closes the fuel inlet and outlet valves and then applies heat, without a relief valve, the heater is very likely to malfunction (with or without risk to people; remember that fuel oil is generally hot, exceeding 100°C/212°F).

If the steam control thermostat is located in the heater itself, this overheating can be avoided (provided the solenoid or thermostatic control valve is not lost, which would cause the temperature to rise to the maximum temperature of the feed steam to the heater), but expansion will still occur because the fuel entered at a low temperature and rose to the operating temperature.

If the thermostat is located outside the heater, in the outlet circuit, the temperature will be even higher, and so will the risk. We must ensure there is a relief valve.

There are several types of steam heaters with a vessel. In all of them, the problem of the difference in expansion between the vessel body and the tubes is generally taken into account. The tubes, being in contact with the hotter steam, will expand more than the vessel itself.

The steam will be controlled by a thermostat that will activate a solenoid valve or a thermoregulating valve. Generally, the condensate will be discarded to prevent contamination of the boiler feedwater. The condensate will be controlled by a steam trap, which, being a float trap, will only allow condensate to pass through, with very little steam loss (thermodynamic traps consume steam to operate).

It is advisable to frequently check the appearance of the condensate for fuel oil leaks, as there is a high risk of contaminating the boiler water with fuel oil (which is very harmful) when the fuel pump is turned on, which raises fuel pressure in the heater.

This occurs when the boiler's steam pressure is lower than the fuel

pressure inside the heater. **When contamination occurs, a "halo" appears floating on the water in the visual level tube, or the fuel itself may be visible in the level tube.** This can cause boiler water carryover, odor in the steam, or worse, burn out a tube due to lack of heat transfer.

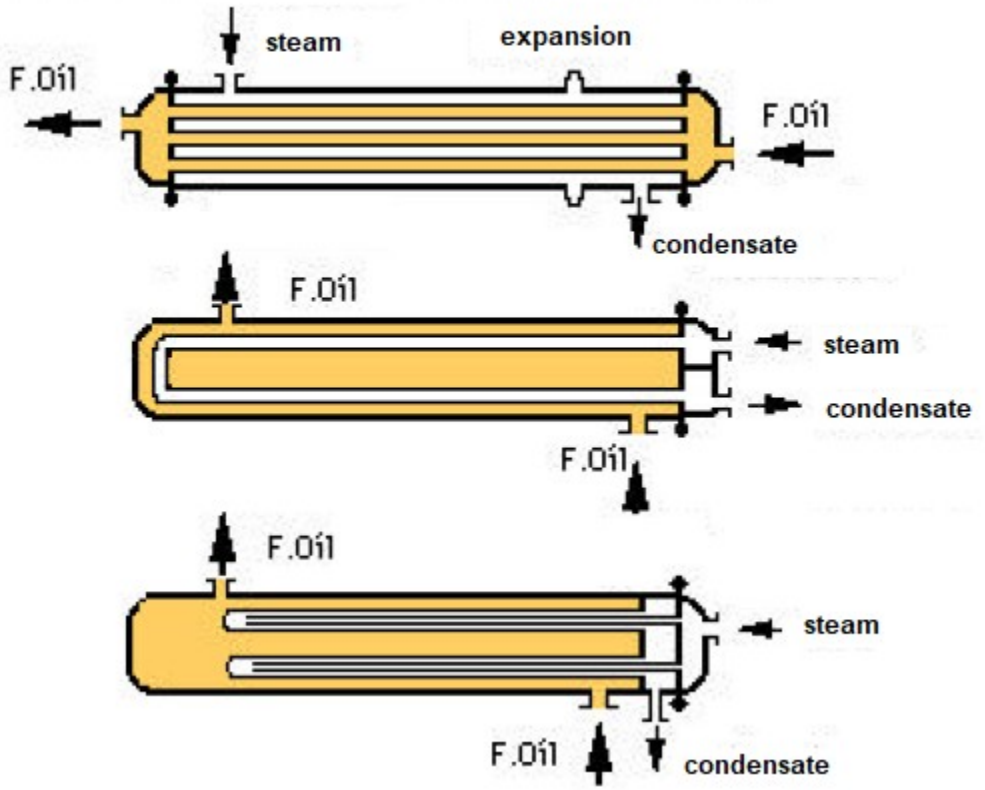
To prevent fuel from entering the boiler through leaks from the heater, it is advisable to install a check valve in the steam supply to the heater (perhaps with a Teflon seat to ensure a good seal), a valve that will be connected after the steam regulation system, in an area where its effectiveness can be checked.

Sometimes, annual cleaning of the fuel-side heater is advisable to remove carbon deposits that impede efficient heat transfer. This can be done mechanically with a turbine system (sometimes preceded by a chemical treatment using hot trisodium phosphate circulated for several hours on the fuel side of the heater with an external pump, ensuring this solution does not enter the fuel system).

Heater corrosion typically occurs on the steam side, in the condensate collection area.

Therefore, the heater should have condensate extraction at the lowest point of the steam chamber to prevent condensate from accumulating, especially when the heater is shut down (when the steam is cold or closed and air is allowed to enter).

HEAVY FUEL OIL STEAM HEATERS



In **auxiliary or main electric heaters**, if the system is based on a vessel with internal heating elements, the problem is exacerbated.

Since electric heating elements reach high temperatures, if there is no heat dissipation, this temperature will increase (in a steam heater, the maximum temperature will be that of the saturated steam in the boiler itself, and the maximum temperature that the fuel oil can reach, while not ideal, will not be as high as with electric resistance heating).

There are several aspects to consider here:

1.- **A high-temperature thermostat must be installed within the electric heater itself to prevent dangerous overheating.** This thermostat should cut off slightly above the operating thermostat and be of the manual reset type, meaning that once it trips, it must be manually reset to alert the boiler operator of the problem.

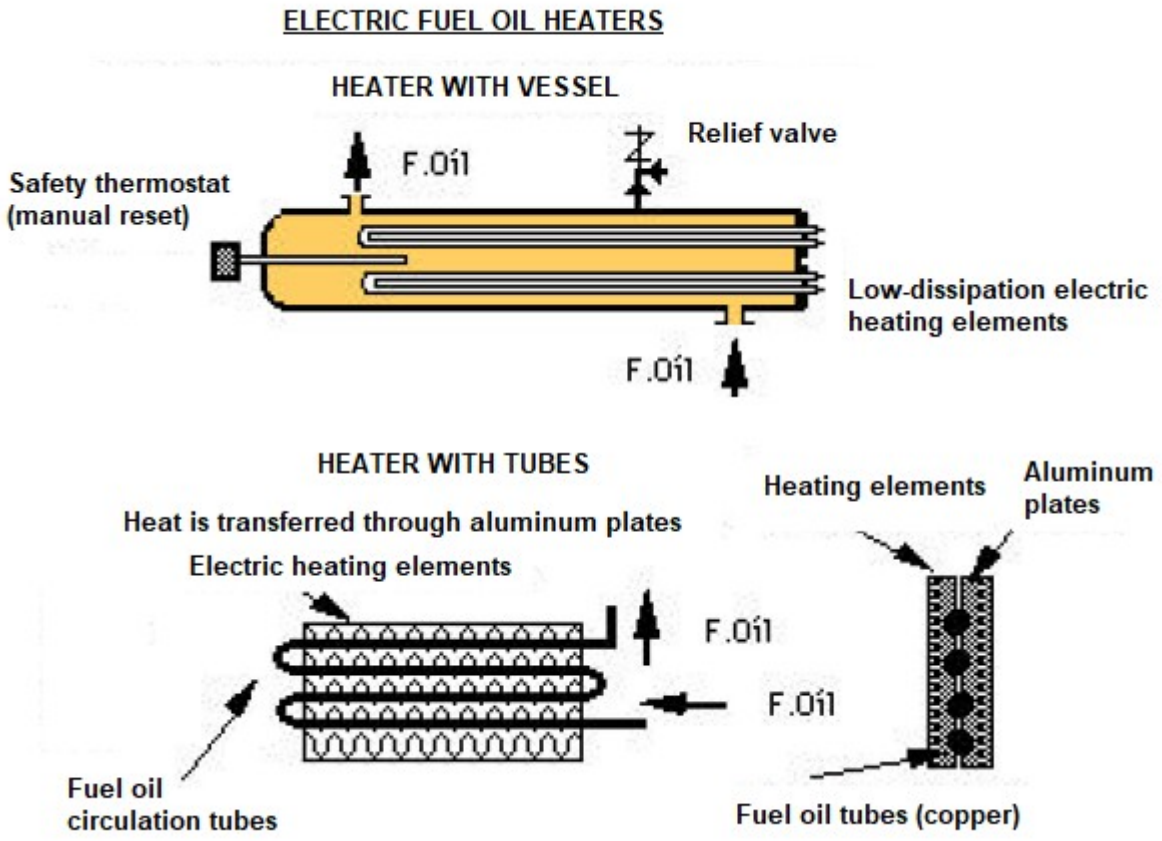
This high temperature not only burns the fuel oil or the heating elements but can also produce high pressures if the system lacks a relief valve, potentially causing the heater to explode.

This high-temperature thermostat between the heating elements also protects them if the heater is ignited without fuel circulation. If this were to happen, the elements would burn out due to lack of heat dissipation.

2.- **It must have a relief system to absorb the hydraulic expansion of the heating** in case it is not connected to the fuel system (and also in case the high thermostat fails or the contactor gets "stuck", causing the temperature to rise with the heater not connected),

3.-**The resistors must be suitable for heating viscous liquids** (the dissipation with area cm2, **must be low enough so that it does not burn the resistors and does not burn the F. Oil, making "scales" that will wear out the pumps**, the atomizing nozzles or block some solenoid or relief valve duct- Generally this dissipation is much lower than the common resistors used for

heating water such as in water heaters, in the order of 3 to 5 watts/cm2).



In some electric fuel heating systems, to avoid risks such as fuel burning due to lack of circulation and excessive heat dissipation by the electric heating elements, the heaters are made of tubes through which the fuel circulates. These tubes are immersed in a heat-conducting metal mass, which is heated by electric heating elements.

In any case, there is an extra, non-externally adjustable safety thermostat that conveniently has a manual reset; that is, once it trips, it must be "reset" by the operator (so that they are aware of the situation.

When a fuel is heated above the recommended atomization temperature (to achieve complete combustion), the problem is generally due to a malfunction of the burner system (it is not advisable to heat heavy fuel oil above 155ºC (311°F), since from that temperature onwards, problems begin to arise due to the formation of fuel "scald" which causes various problems in the system: wear, blockages of filters, ducts, solenoids, etc.).

Do not attempt to troubleshoot burner adjustment problems

by overheating the fuel.

Regarding the cost-effectiveness of heating fuel oil, it's important to note that some of the energy supplied to the fuel as heat to lower its viscosity and achieve good atomization is added to the heat released by the fuel itself. **However, the most significant factor is the energy source used for this heating: electrical energy is clearly the most expensive (while using the boiler's own steam is the most economical).**

The specific heat of fuel oil (Cp: approx. 0.5 kcal/kg/°C, heat required to raise 1 kg of fuel by 1°C) is half that of water. If we use steam, for every 1 kg of steam, we can heat 10 to 11 kg of fuel (to over 100°C).

If we use electricity, for every 1 kWh (860 kcal/kWh), we can heat about 17 kg of fuel under the same conditions. However, to generate 1 kg of steam, generally only about 0.070 kg of fuel oil will be sufficient.

This shows how much more economical it is to heat fuel with steam (since, to equate heat, approximately 0.120 kg of fuel oil will be sufficient for every 1 kWh of combustion in a boiler with a 0.85% Total Efficiency at LHV).

Fuel contamination problem:

The most common fuel contamination is water, which can enter the fuel tank through seepage, rainwater, condensation, or leaks from heating coils (although there can be other types of contaminants, from sand to the mistake of "pouring" cleaning solvents or simply used oils into the tanks, which will later make the situation very dangerous due to the volatility of these components).

When the water content in fuel is very low (less than 1%), and the emulsion is good, it improves combustion quality (there is an improvement in atomization; in fact, there are machines that can emulsify water up to 3%).

However, when the percentage of water exceeds a certain limit, "sparks" begin to appear in the atomization cone, until a point is reached where combustion becomes unstable and the burner shuts down.

When using fuel additives, the problem is that water is very difficult to remove by "decantation," since fuel additives tend to emulsify the water contamination with the fuel.

Therefore, it is not advisable to add fuel additives if the tank is prone to water penetration and needs to be removed as such.

Another factor that makes water extraction difficult is the **density of heavy fuel** oil when it reaches 1 (1 liter = 1 kg).

If this happens, the water doesn't separate from the fuel and sinks to the bottom (water pools form at any height in the tank).

To separate the water in this case, **there's no other option than to mix this heavy fuel with a lighter fuel** (heating fuel oil, diesel, or gas oil) in a percentage that lowers the density to less than 0.98 (after thorough mixing, sometimes by gently heating the fuel and then letting it rest for several hours, the water will settle).

As for other types of contamination, each case must be handled accordingly, often requiring the extraction of the fuel with a barometer and its return to the supplier (with the corresponding claim).

Given all this, it is advisable to have a tank for the "receipt" of fuel and take a sample at the time of receiving the fuel (in agreement with the supplier and keep it sealed until the fuel is used without problems, and in case there are problems, the sample will show whether the problem was before or after the supply).

Fuel Receipt:

Fuel receipt control is very important. It can be **controlled volumetrically** (since the price is given per volume at a specific temperature), but because fuel volume varies with temperature, this task becomes somewhat complicated in each case because temperature adjustments must be made (using tables for each fuel).

This volumetric measurement is taken on the tanks, both for transport and for receipt, using previously calibrated rulers.

At the end of this manual, there is a mathematical method for calculating cylindrical tanks, but tanks can be oval or deformed during installation.

Therefore, it is advisable to **calibrate the rulers using water**, which is carefully controlled as it is introduced into the tank for calibration. This is the safest method for horizontal tanks.

A simple, relatively accurate way to control this is to weigh the transport vehicle before and after unloading; the volume will be approximately the product of the weight in kg and the specific volume in L/kg (or the inverse of the density, a value that should be supplied by the fuel seller), which is usually very easy to do.

The fuel receipt includes not only the volume (for which you pay), but also the characteristics of each type of fuel.

Among these characteristics, depending on the fuel, it's important to check the viscosity. This allows you to see how well it adapts to the pumping and atomization system, as it measures the effort required to propel it through the pipes.

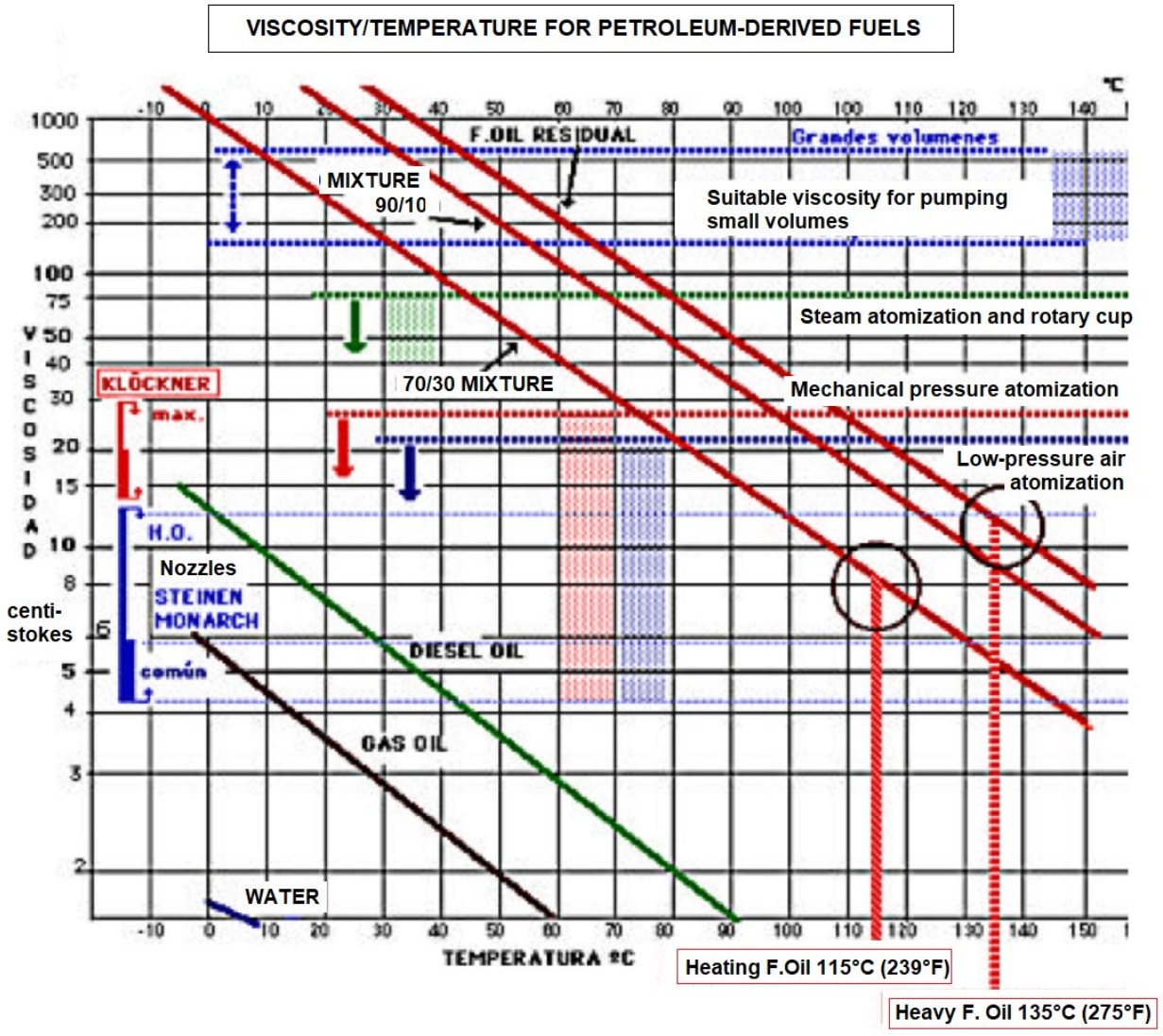
However, this value is related to the temperature at which viscosity is measured, which generally decreases as the temperature rises (i.e., it is easier to pump).

The fire point is the temperature at which the first combustion occurs when a flame is brought near the surface of the fuel. Since the safety standards for the use of each fuel allow us to work safely (remember that a heavy fuel oil with a flash point should not have volatiles that could cause a combustion explosion or fire when heated for pumping or atomization, since it is possible that due to an error in supply a fuel with other characteristics is delivered; the introduction of additives or other fuels with a low flash point should not be allowed either, it is dangerous).

Other analyses can be requested, such as the Higher and Lower Heating Values, maximum sulfur content, etc.
A good practice upon receiving the fuel is to keep a sample (a tightly sealed 1-liter bottle), in agreement with the supplier, so that if any fuel-related problems arise, this sample can be analyzed and compared with the analysis performed on the fuel in use.

In the following graph, you will see the most **suitable viscosities for pumping different fuels** (expressed on the left side of the

graph in centistokes or kinematic viscosity, an international way of expressing viscosity, which can also be expressed in other ways: Engler degrees (European), Saybolt Universal (U.S.A.), Saybolt Furol (U.S.A.), Rewood (England), etc., which can be converted from one to another using tables), as well as the **best viscosity for atomization depending on the fuel and the type of burner** (the most common burners or mechanical nozzles are indicated on the left side of the graph).



The viscosity of water is shown in the lower left part and the viscosity for heavy oil is shown in the lower right part, which is around 135°C (275°F) for mechanical atomization (with nozzles suitable for this, especially in small burners the nozzles will be indicated as H.O. or Heavy Oil, which means "heavy oil or fuel").

Residual fuel oil is heavy fuel oil (or No. 6). A 70/30 mixture would be

heating fuel oil. Diesel oil has a higher viscosity than gas oil and is also more difficult to burn.

Never accidentally preheat gas oil and diesel in a burner that burns residual fuel oil. This can cause a combustion explosion upon ignition due to the vaporization of the lighter fuel.

If it is necessary to mix heavy heating fuel oil with gas oil or diesel oil, mix thoroughly before pumping it to the burner (by mechanical agitation or with air).

The percentage of lighter fuel should not be too high; generally, it should not exceed 20%. Otherwise, there is a risk of combustion explosion (if lighter fuel is preheated instead of the mixture).

BURNER HYDRAULIC CIRCUIT (fuel circuit)

Let's look at a sketch of a fuel oil system with a mechanical atomization burner with return flow control (although there will be many hydraulic circuits, depending on the type of burner, they all have the basic elements in common: tanks, pumping, heating, and **fundamentally all the control and safety elements**:

As we said, the automatic burner owes its operation to an **electrical-electronic programmer**, which performs all the sequences and controls or **receives all the signals from the safety elements:**
It checks that the fuel cutoff valves (in large burners there may be two serial cut off valves) are closed and will only be opened, feeding the atomization, if all the necessary requirements are met, such as: before strat there is a **sufficient water level**,

1.- first perform a pre-air purge (expel any remaining fuel gases from the combustion chamber; this operation involves changing the air in the combustion chamber and pipes 4 times or for 90 seconds with the "damper" (air inlet) open to 60%).

- The programmer will **monitor whether there is air for combustion** or airflow (without air there will be no combustion, but we will flood the home with fuel until the flame sensor closes the safety valve),

- Meanwhile, it will also receive the authorization that there is an **adequate temperature in the fuel** (an "anti-smog" thermostat, to avoid a cold start).

2.- the air returns to **minimum air for start-up** (a microcontroller monitors the minimum air position to prevent a start with excess air that blows out the flame or with excess fuel, since the air "damper" and the fuel regulating valve, if the burner is modulating, will be linked),

3.- **A pilot light is lit** (there may not be a pilot light). This light is usually bottled gas, and its ignition depends on an electrical transformer that raises the voltage of the normal supply line to more than 15,000 volts, causing a spark that ignites the gas.

4.- **The pilot light will ignite for a few seconds (usually 10 seconds, provided it does not detect another flame or heat source that could ignite it in the home, to prevent a home explosion).**
Its ignition can be monitored by a flame sensor (photocell, which can be infrared to detect gas combustion, photodiode, or valve).

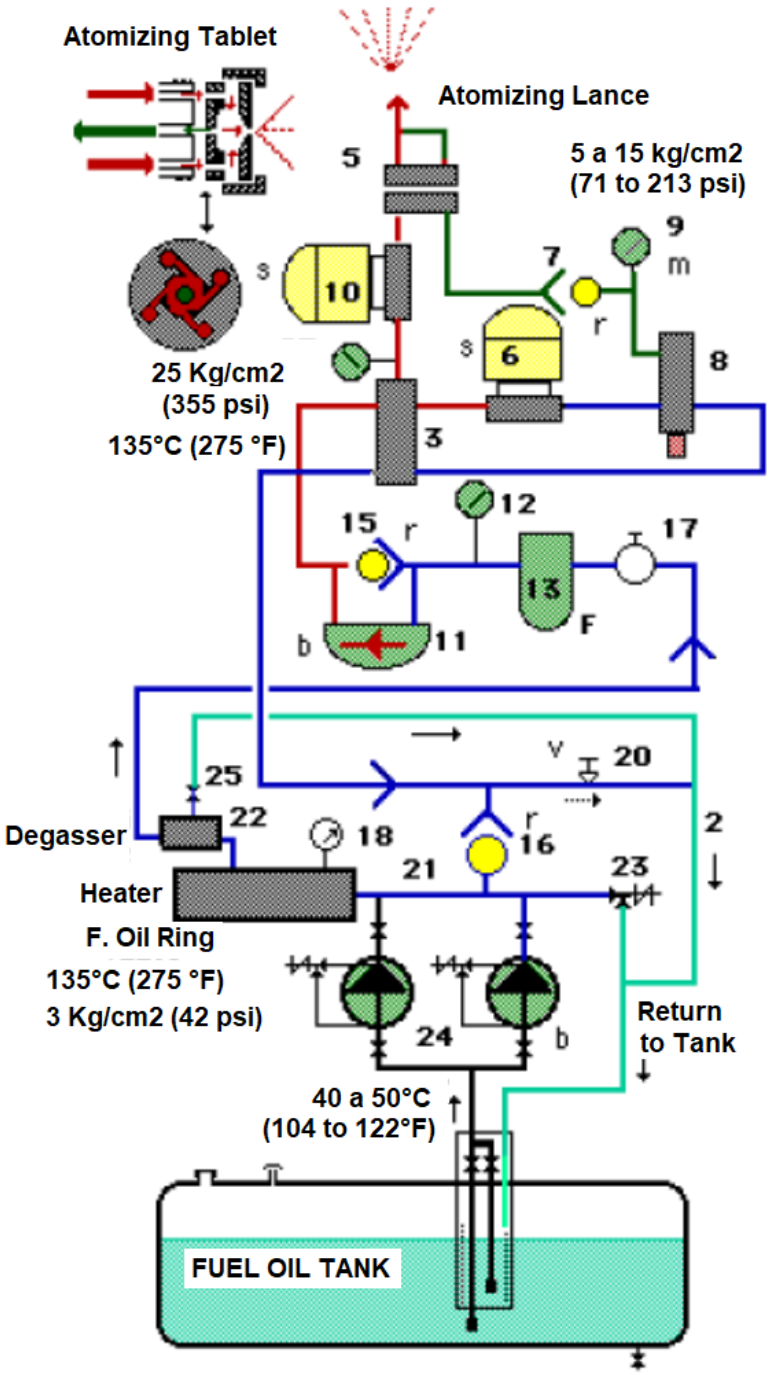
If the pilot light is not detected, the ignition process stops (this may trigger a complete cycle again or trigger a flame failure alarm, depending on the programmer). If the pilot light is not monitored or if there is no pilot light, the next step will be taken.

5.-The fuel supply valves for atomization will open in the idle condition, but **if the flame sensor does not detect the flame in 10 or 15 seconds, depending on the power and whether it has a pilot (15') or not (10'), the fuel cut-off valves will activate (closing) aborting the operation** (the action can be repeated automatically, doing a pre-purge again of shorter duration, depending on the type of burner and fuel).

6.- **Once the main flame is established**, if the burner is modulating, a few seconds will pass before the modulating pressure switch is enabled. This will cause the burner to regulate the power or fuel and air flow according to each steam production need (regulated by the steam pressure).

However, the **flame will always be monitored by the flame sensor,** which, depending on the burner type and power, will take between 15 seconds (small burners) and a maximum of 4 seconds (medium to large burners). **If it does not detect a flame, it will**

immediately shut off the fuel to atomization (performing a new recycle, depending on the burner).



10 6 solenoids

8 return regulator

3 safety relief and cut-off valve

11 high-pressure pump

24 low-pressure pumps

7 15 16 check valve

20 manual return regulator

5 lance coupling

23 relief valve

22 degasser

9 16 25 pressure gauges

25 gas return valve

13 filter

17 valve

Generally, **if the burner fails** during one of its operations (after the recycle cycle, if applicable), it will remain off. An indicator light or alarm will usually illuminate, signaling the fault, until the operator presses a button ("reset") to return the burner to its normal operating condition and restart the burner.

It is advisable to check for any problems, which could include: a photocell clogged with soot (failing to detect the flame properly), dirty fuel filters, insufficient fuel, insufficient combustion air (due to

a broken fan shaft), broken fuel hoses, cold fuel, water in the fuel, a malfunctioning fuel pump or air entering the suction line, or a lack of fuel altogether.

There will generally need to be **electrical interlocks between the different operating elements, such as the shut-off valves** (which should generally close in less than 1 second, like solenoids) not being enabled by the programmer if the fuel pumps are off, if the fan is off, induced air draft if there is one, etc.

Similarly, the possibility of electrical faults in the circuits, such as short circuits, grounded wires, etc., must be considered, so that **under no circumstances should the burner shutdown be overridden if the boiler has a low water level**. **If the pressure exceeds the limit, the safety valves will open, but if it runs out of water, the boiler will malfunction: it will burn out or something else related to that, such as an explosion if the conditions are right.**

The sketch above (the atomizing lance drawing) shows a fuel oil system with mechanical atomization and fuel return recirculation regulation (in the atomizing state) to vary its atomization flow capacity without affecting the atomization quality.

The **Fuel Oil tank**, in the case of heavy F. Oil, must have a **heating system** to bring the temperature to at least 50ºC (122°F), to lower the viscosity to that of low pumping (generally a steam coil, surrounding the fuel inlets, with its thermostat and temperature control solenoid).

The thermostats have not been installed here (a fuel heating temperature regulating thermostat, a high temperature cutoff thermostat with reset if it is electric heating and a low temperature protection thermostat or "anti-smog" in case the F. Oil is too cold (turns off or does not allow the burner to ignite).

Note that there is a **"low" fuel pressure ring**, whose function is in heating and supplying the fuel, and a high pump circuit for atomization (which works with the fuel already hot, which makes its job difficult, since the fuel itself is the lubrication of the pump's gears and seals).

There are two solenoid valves: one normally open (No. 6), which allows fuel recirculation when the burner is off, to keep the circuit "hot" almost to the nozzle, and another **normally closed (No. 10)**, which enables fuel to flow to the nozzle for the burner to operate.

There is also another mechanically actuated **safety valve (No. 3),** which has the dual function of closing when the burner shuts off and regulating the maximum pressure of the high-pressure pump for atomization.

Valve No. 8 regulates the combustion capacity, returning fuel, controlled by a modulating motor (governed by a modulating pressure switch) and which also regulates the combustion air intake to maintain the air/fuel ratio.

Low-pressure pumps must have a permanent internal or **external relief valve**, since they are positive displacement pumps. If they do not relieve pressure when the valve is closed, they would build up so much pressure that they would "break" the pipes or any element that cannot withstand the pressure, or even the pump shaft, or in the best-case scenario, they would trip the motor's thermal overload relays.

The fuel heater (F. Oil), generally if the boiler is relatively large, will be a **combined electric-steam heater or two separate heaters, one steam for normal operation and one electric for starting.**

The deaerator at the outlet of the heater allows the extraction of gases and water vapor evaporated by the high temperature (since the saturation temperature of water is higher than that corresponding to the low pressure).

If these gases interfere with the high-pressure pump, it causes alterations in the high pressure, resulting in poor atomization.